Comparison of the Effects of RAS vs. Kain-Fritsch Convective Schemes on Katrina Forecasts with GEOS-5

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Timothy L. Miller, NASA/MSFC
Charles Cohen, USRA/MSFC
Jessica Paxton, UAHuntsville (now NCAR)
F. R. (Pete) Robertson, NASA/MSFC

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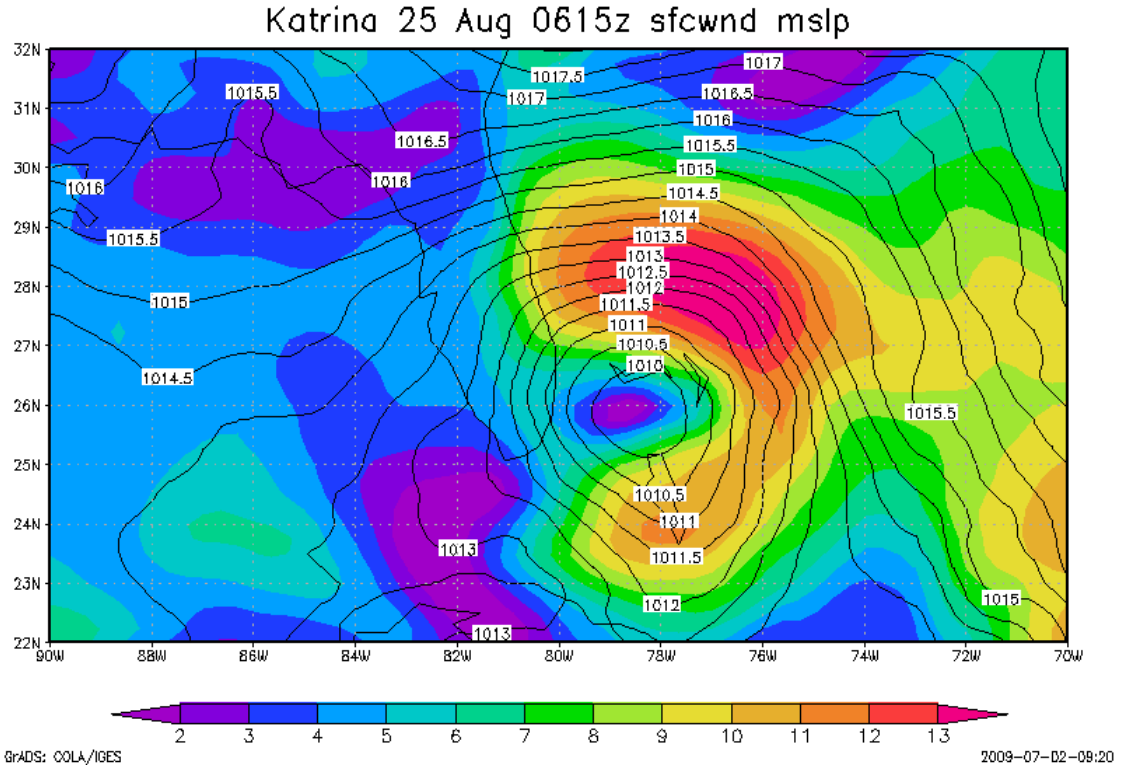
Background

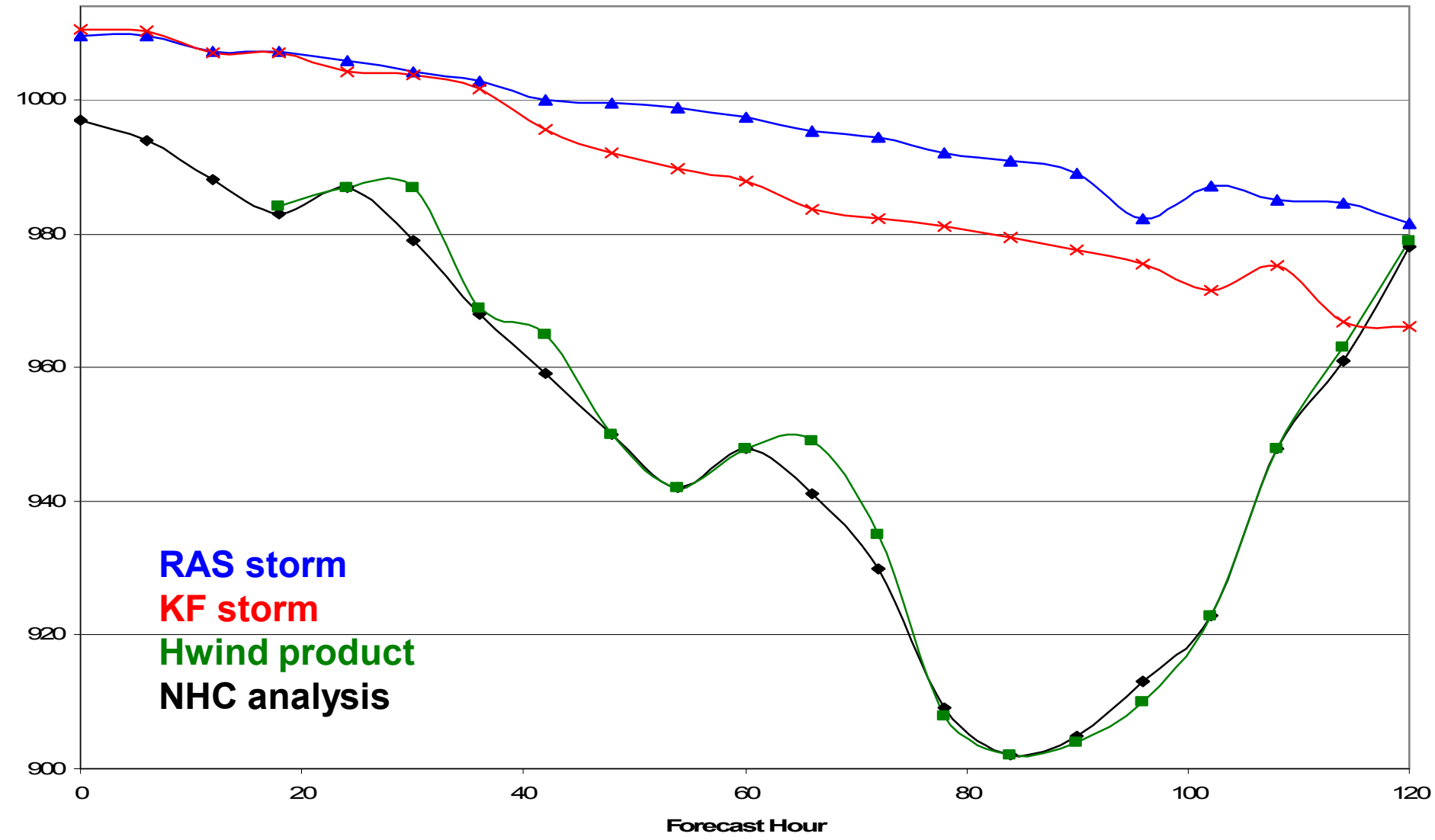
- As global models close in on mesoscale resolution, it is necessary to consider the appropriateness of convective parameterization schemes
  - 0.25-degree resolution is not yet adequate to explicitly resolve cumulus convection
  - Schemes appropriate for coarser resolution may no longer be appropriate for “high” resolution
  - For example, the Arakawa-Schubert scheme (including the “relaxed” one, or RAS) becomes difficult to justify
    - Add some bullets here
  - The Kain-Fritsch (K-F) scheme was designed for models with ~25 km resolution, although some modifications for tropical convection were necessary for this work
- Cohen has implemented K-F in GEOS-5, targeting especially high-resolution simulations. A case study is shown here of the Katrina hurricane of 2005 at 0.25 degrees latitude resolution.

Initial Conditions

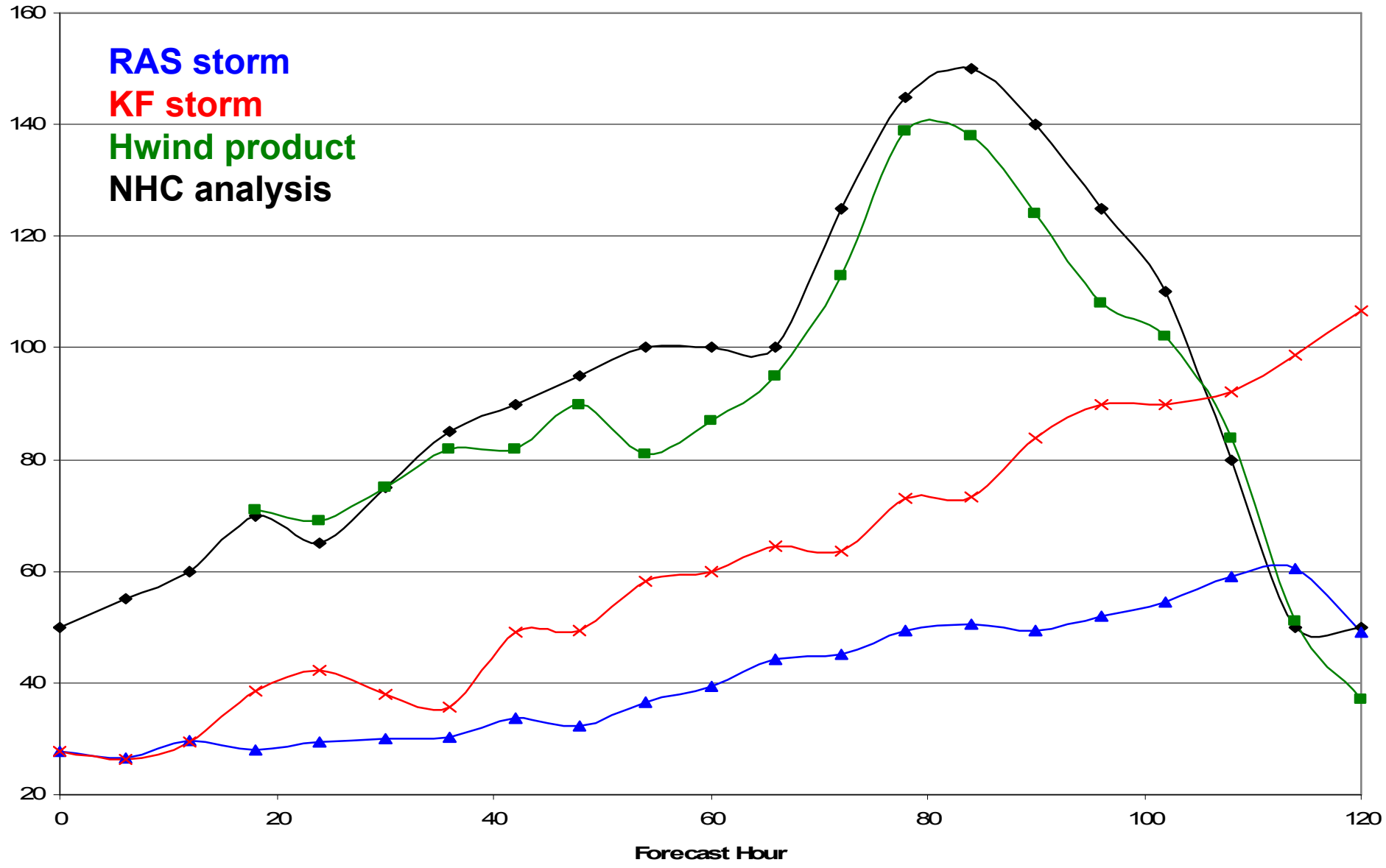
- Initial condition for all runs is the result of a 6-hr standard GEOS-5 (i.e., with RAS) 0.25-deg forecast from GFS initial condition.
  - Our initial condition is 25 Aug 06z.
  - Max wind 27 kts; min SLP 1010 mb (vs. Best Track 50 kts, 997 mb)
- Storm was offshore Florida (Atlantic side)
- Forecasts were made with 0.25-degree resolution with RAS and with Kain-Fritsch implemented, respectively
- It is noted (with apologies) that some results shown here are from a near-current version of GEOS-5, while others are from an older version ("patch 11"). While details of the fields may vary slightly, the results' general descriptions and conclusions do not change.



Minimum SLP

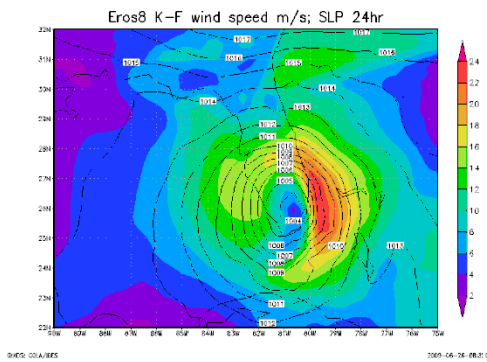

1000
980
960
940
920
900
0
20
40
60
80
100
120
Forecast Hour
RAS storm
KF storm
Hwind product
NHC analysis

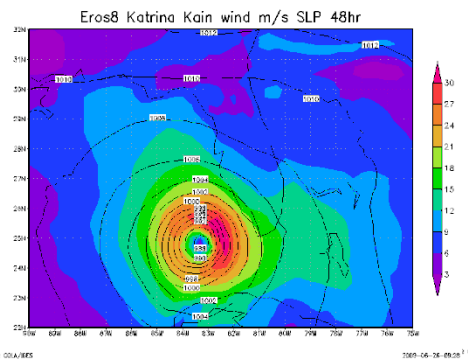
Max surface wind (knots)

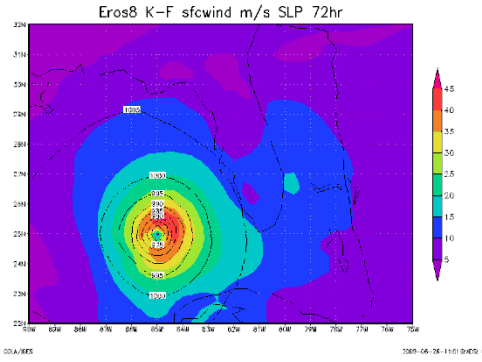


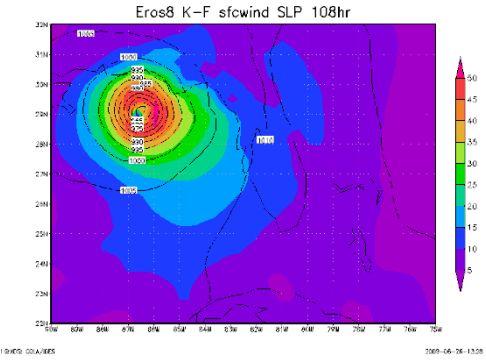
Surface wind speed, SLP fields

With Kain-Fritsch scheme:

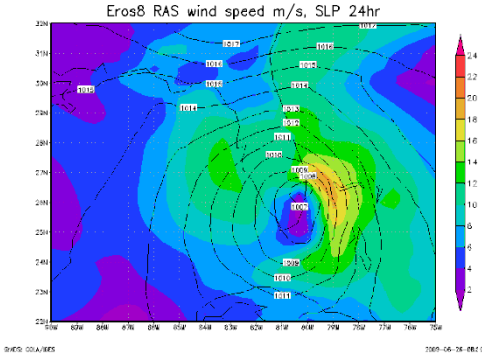


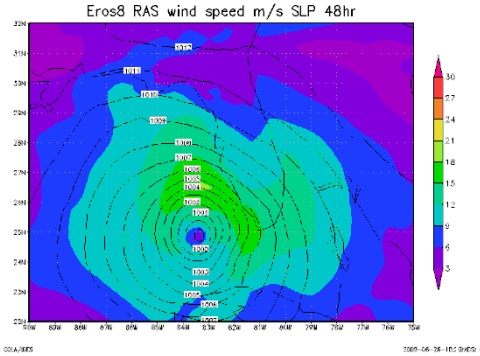


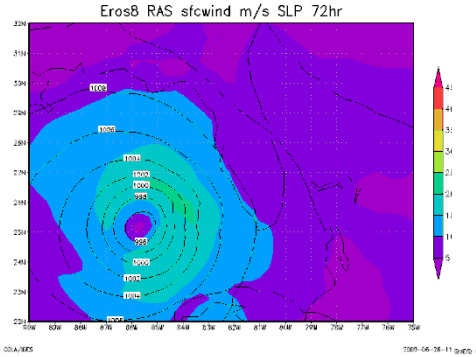


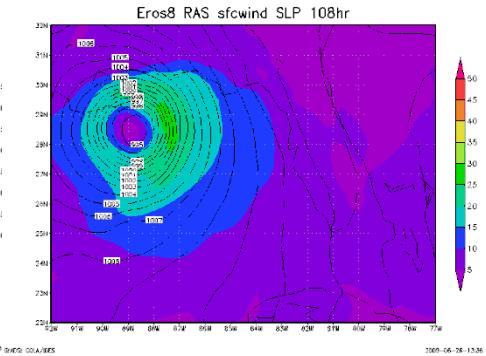


With RAS scheme:







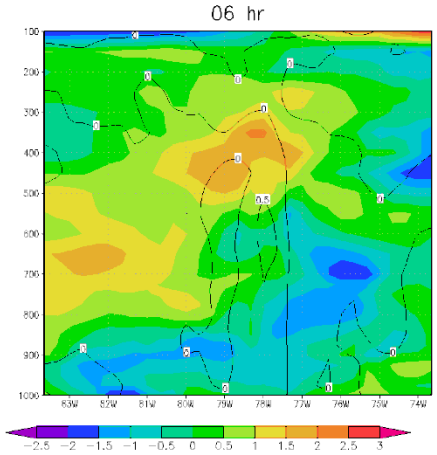


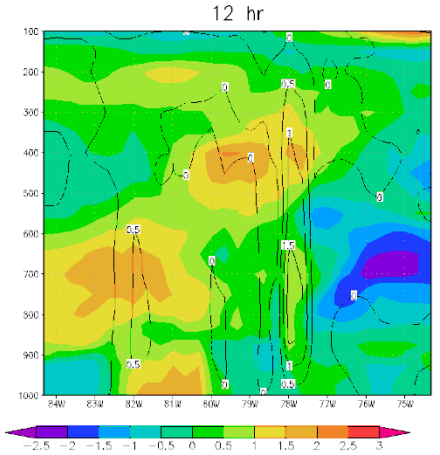
KF

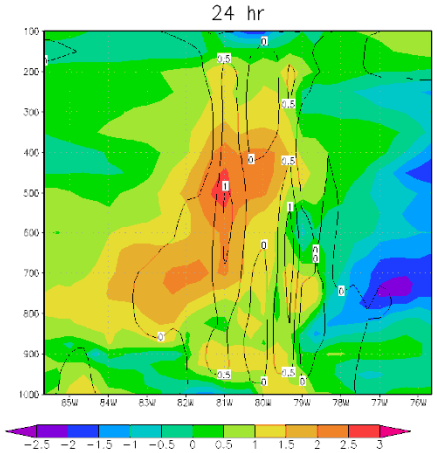
W-E Cross-section

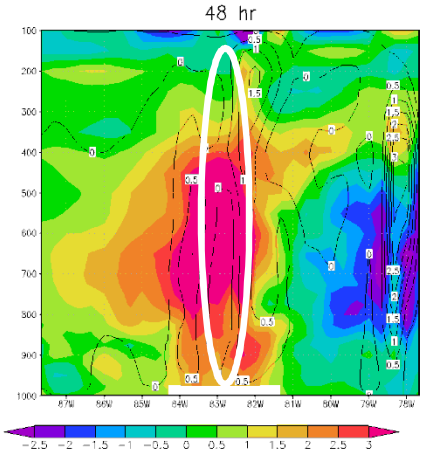
Temperature anomalies and vertical velocities through storm center.

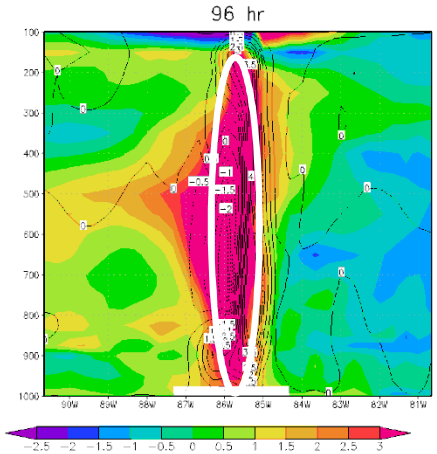
Note color contour interval.

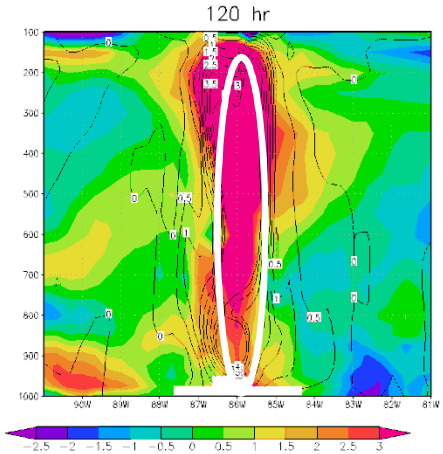






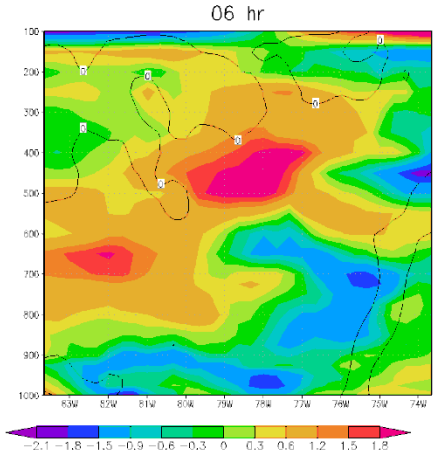


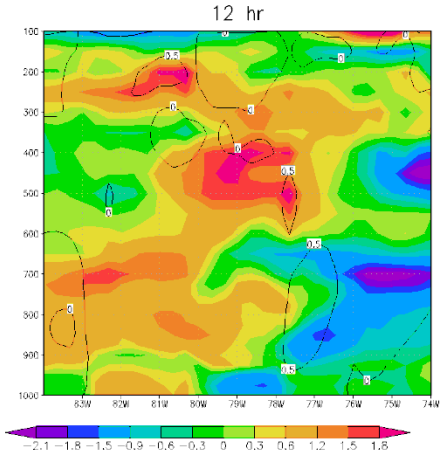


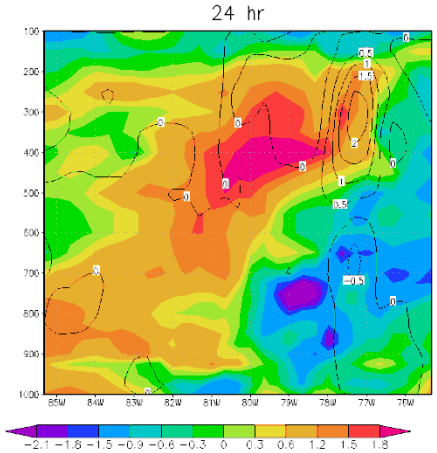


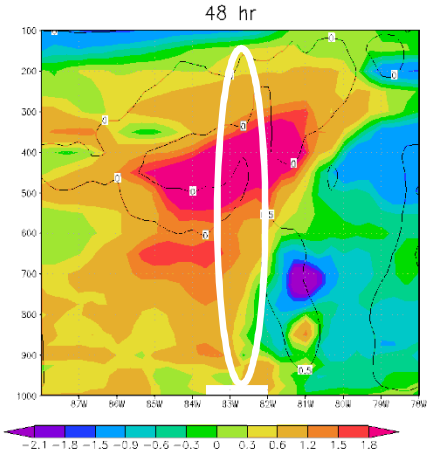
RAS

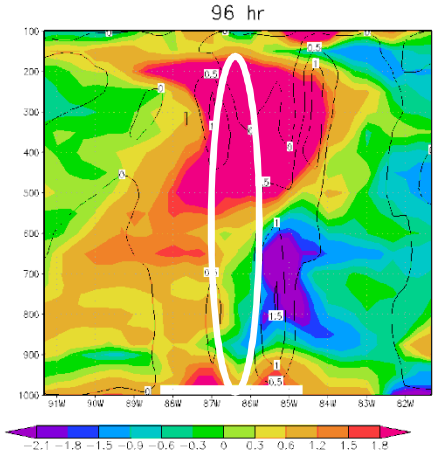
Temperature anomalies and vertical velocities.

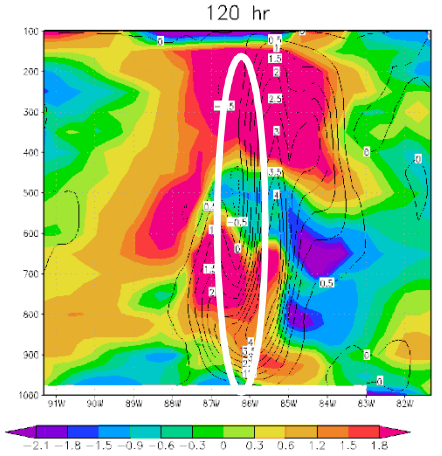






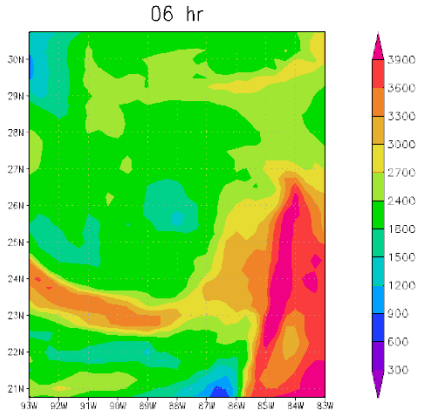


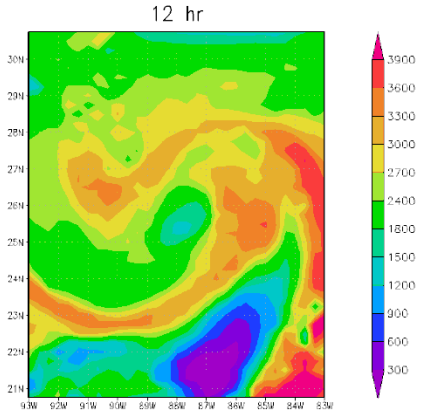


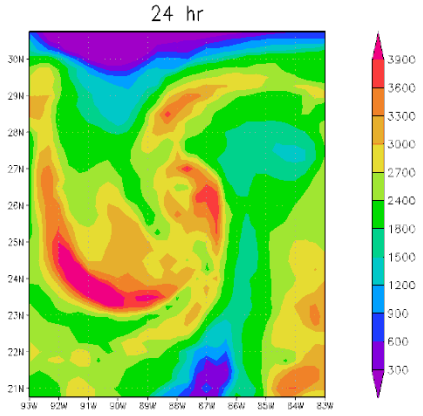


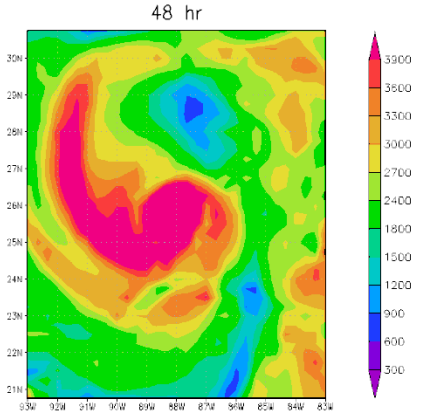
KF

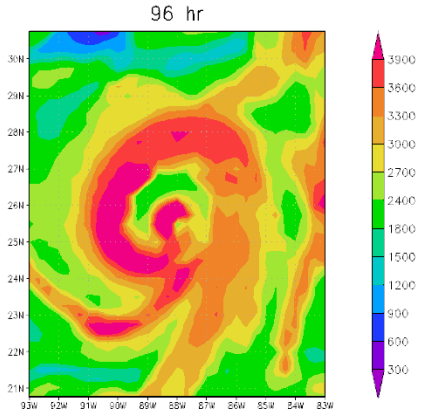
Surface-based CAPE. Units are Joules per kilogram. Note: Lat and lon labels on this and the next figure are incorrect. Figures are storm-centered.

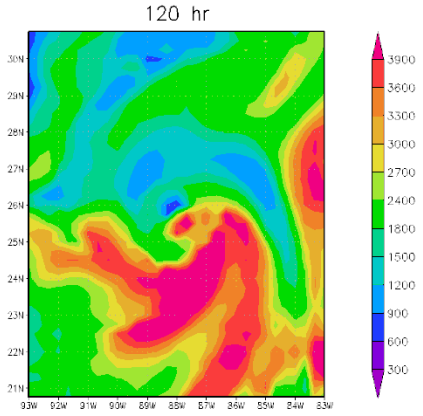






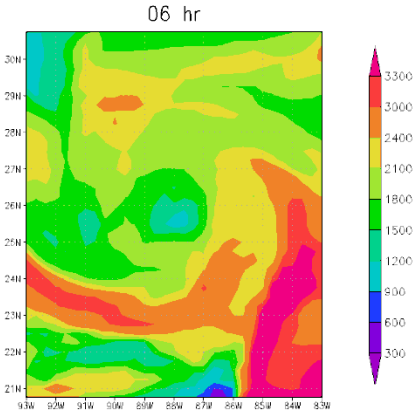


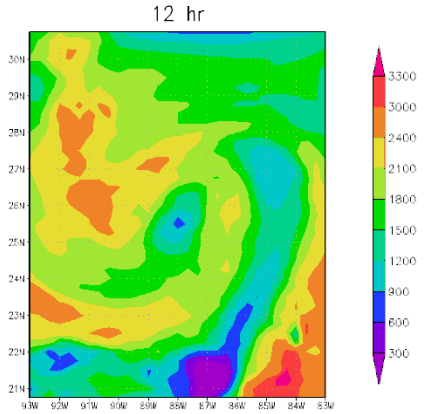


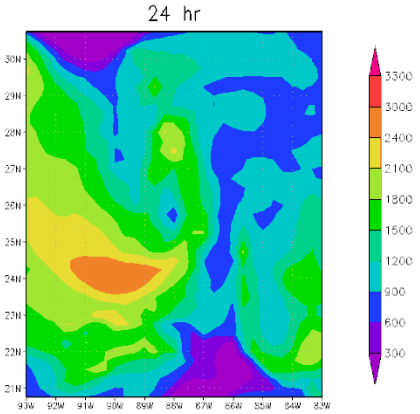


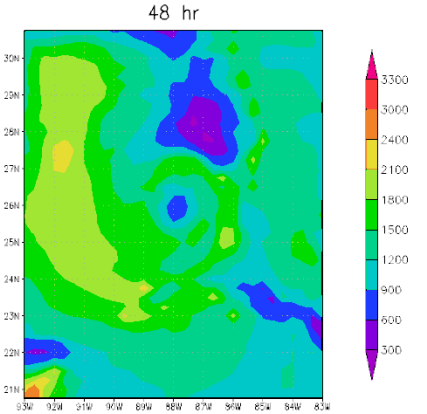
RAS

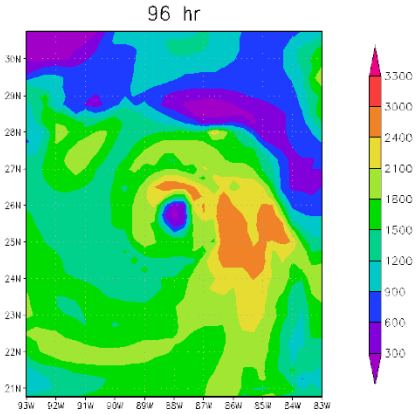
Surface-based CAPE. Units are Joules per kilogram.

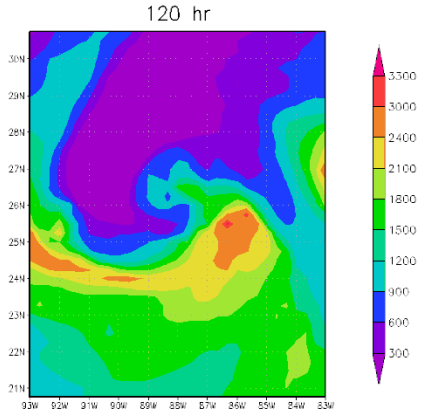






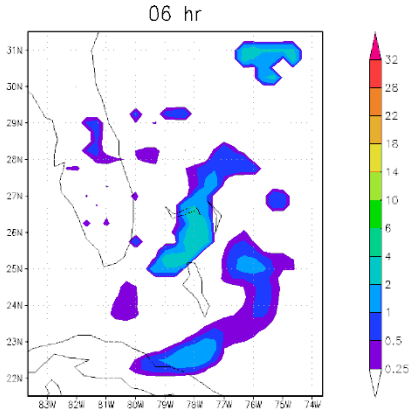


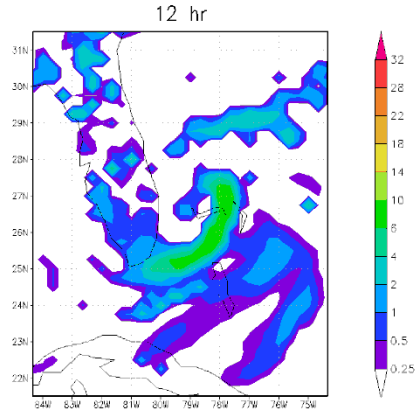


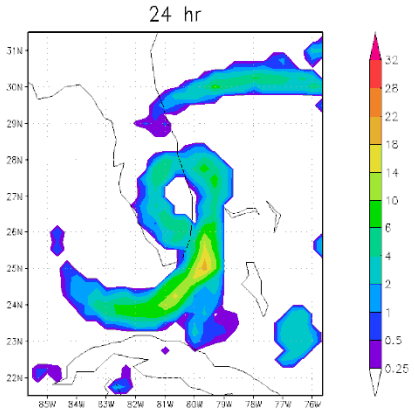


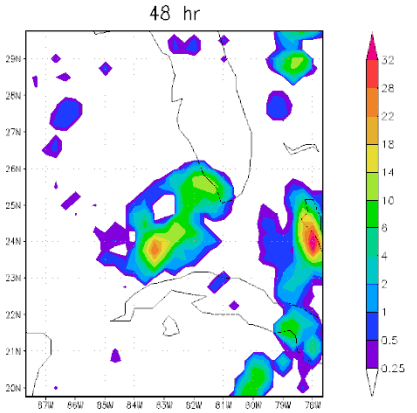
KF

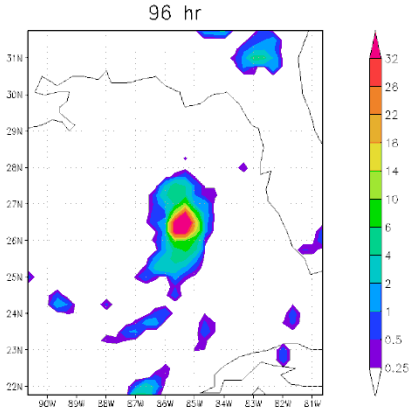
Precipitation

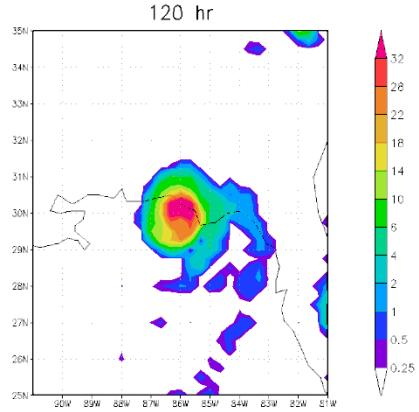








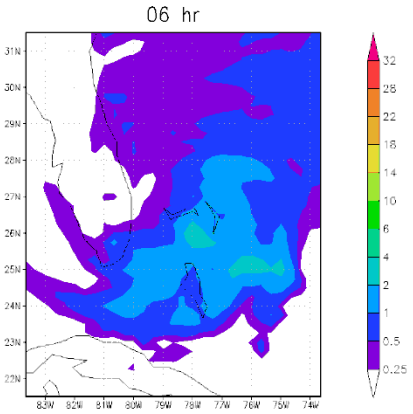


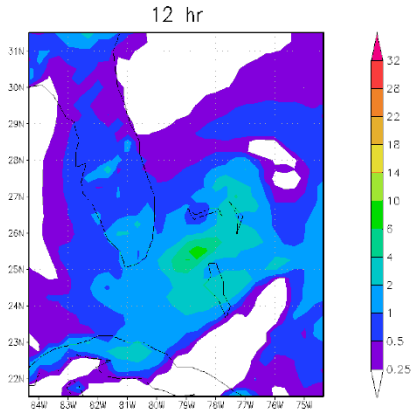


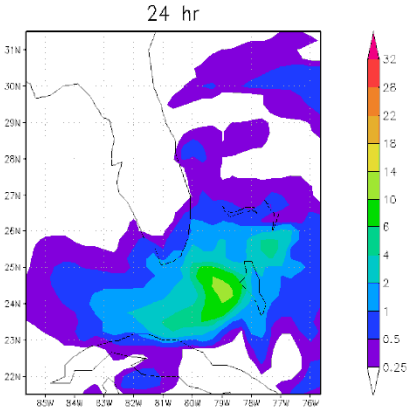
RAS

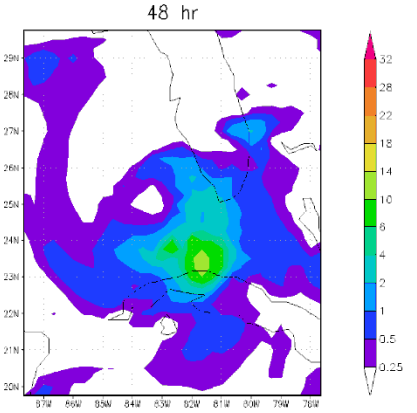
Precipitation

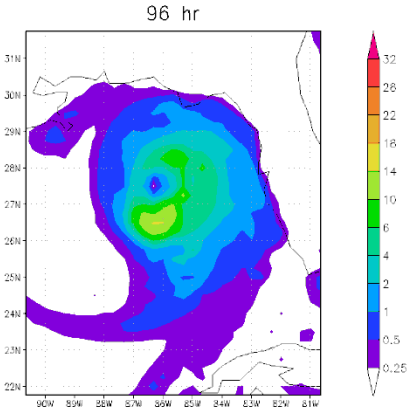
6-hour averages,
centered on the
given forecast time,
in mm/hour

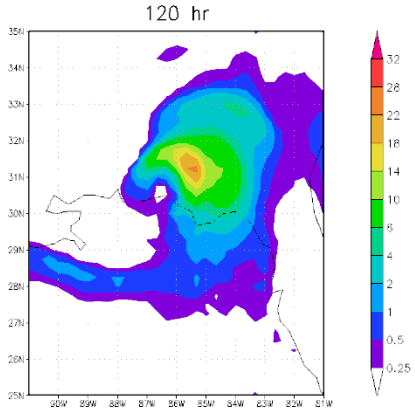




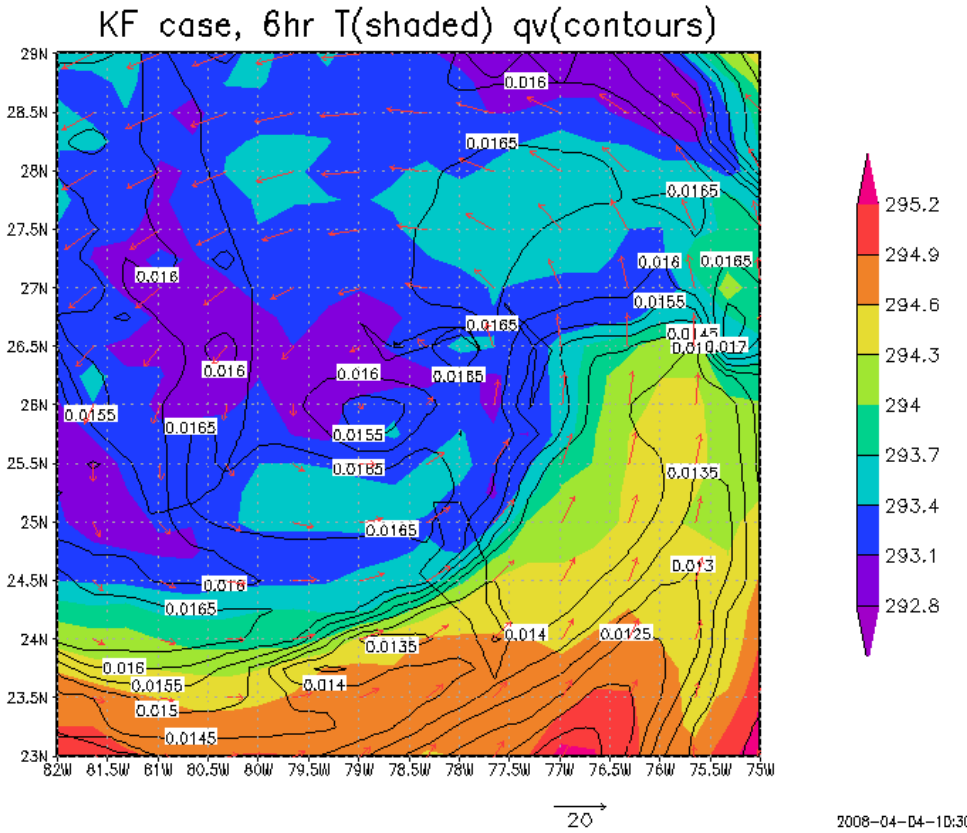


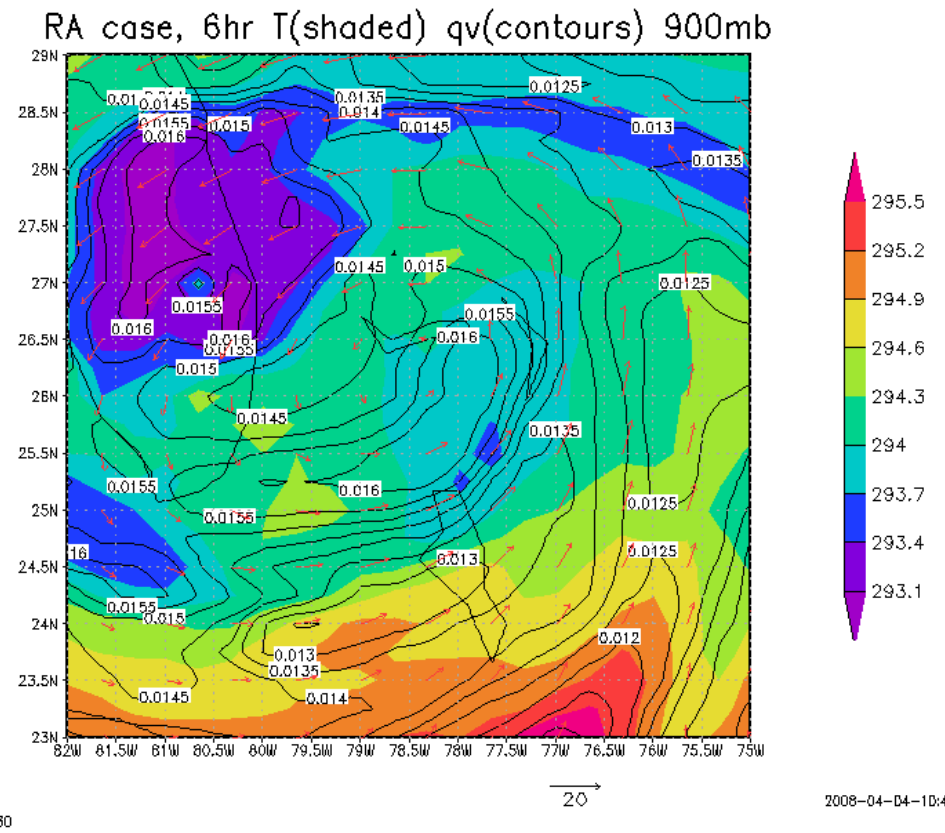






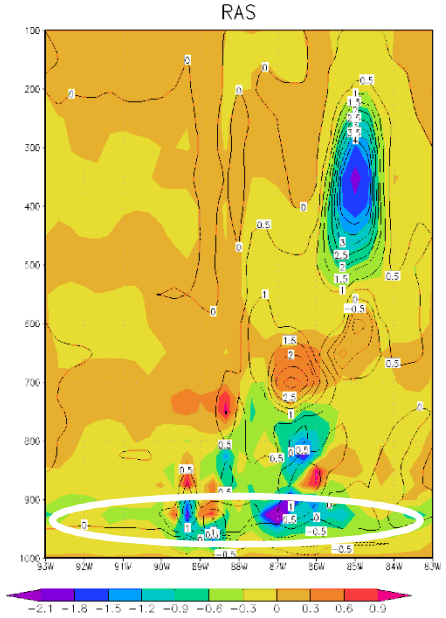
900 mb T, water vapor at 6 hours

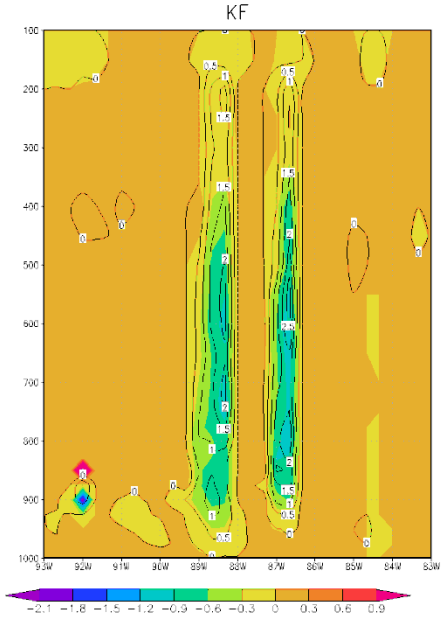


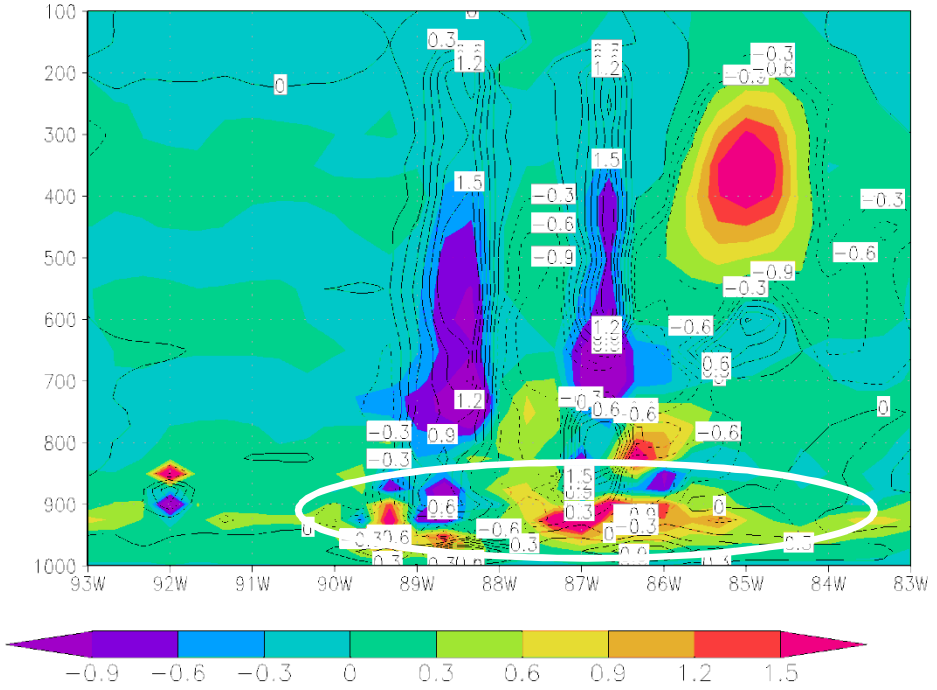


RAS & KF

Water vapor tendencies and temperature tendencies at 24 hours. Lower figure is the difference, KF – RAS.

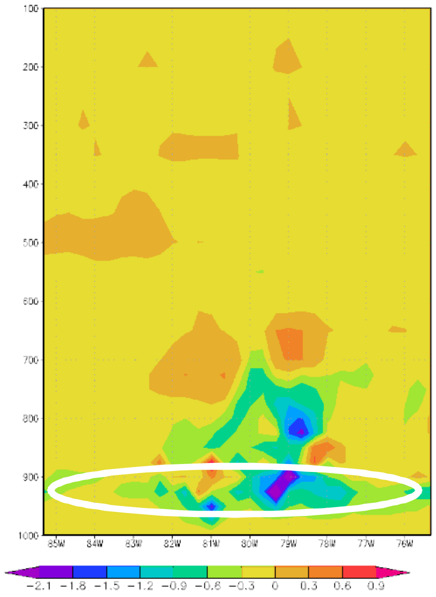


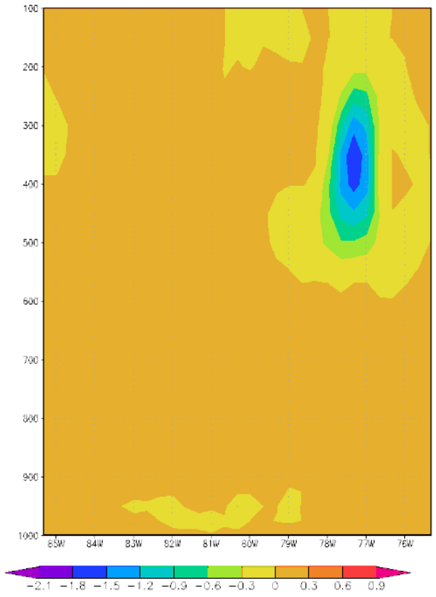


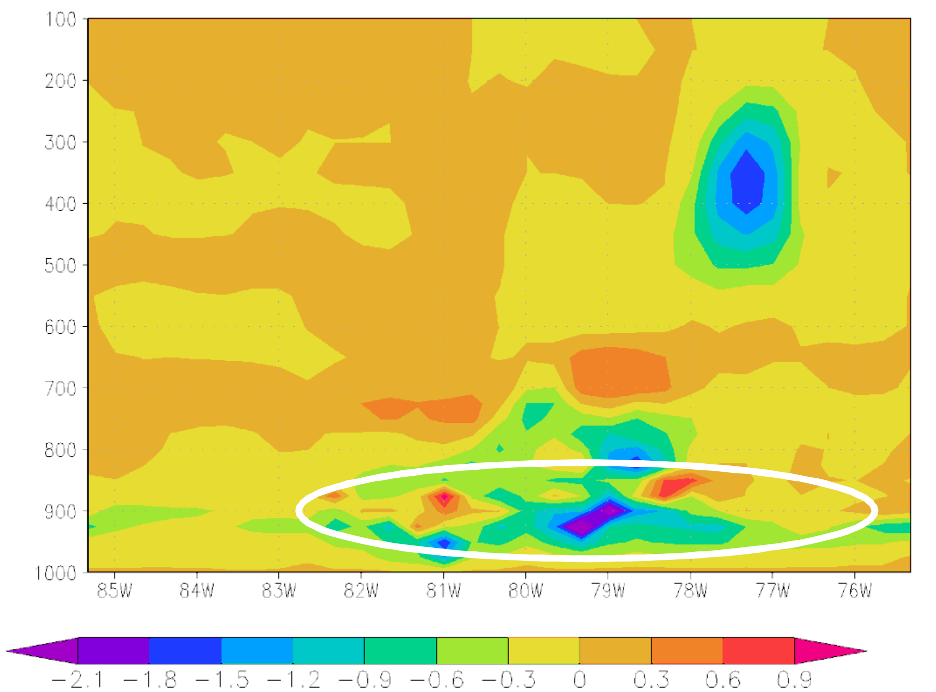


RAS

Water vapor tendencies due to convective scheme and grid scale processes, respectively. Lower figure is the sum.







Conclusions

- Global forecasts were made with the 0.25-degree latitude version of GEOS-5, with the RAS scheme and with the Kain-Fritsch scheme. Examination was made of the Katrina (2005) hurricane simulation.
- Replacement of the RAS convective scheme with the K-F scheme results in a much more vigorous Katrina, closer to reality.
  - Still, the result is not as vigorous as reality. In terms of wind maximum, the gap was closed by ~50%.
- The result seems to be due to the RAS scheme drying out the boundary layer, thus hampering the grid-scale secondary circulation and attending cyclone development.
  - The RAS case never developed a full warm core, whereas the K-F case did.
- Not shown here: The K-F scheme also resulted in a more vigorous storm than when GEOS-5 is run with no convective parameterization.
- Also not shown: An experiment in which the RAS firing level was moved up by 3 model levels resulted in a stronger, warm-core storm, though not as strong as the K-F case.
- Effects on storm track were noticed, but not studied.